Missouri Department of Transportation

Bridge Division

Bridge Design Manual

Section 3.50

Revised 04/26/2001

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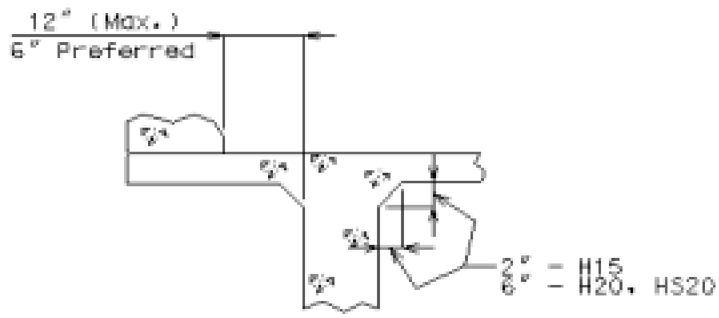
Note: Use Elastomeric Bearing Pads for new designs, see AASHTO Article 14.6.

General:



Moment of Inertia Method

Moments are taken about top of the effective concrete.

The following analysis of T-Beam sections by the moment of inertia method involves a procedure that has been found to be less laborious than the usual procedure used in this office, as taken from “Concrete Engineers Handbook”. To evaluate ‘y’ by the usual method, moments are taken about the neutral axis. In this analysis, moments are taken about the top of the effective concrete.

Location of Neutral Axis (Evaluation of ‘y’)

The neutral axis lies at the center of gravity of the effective composite area.

Assume Neutral Axis to lie in stem. Take moments about top of effective concrete. (Wearing surface out.)

Item	*Area*	*Arm*	*Moment*
Flange outside of steam	$T(F + F')$	$\frac{1}{2} T$	$\frac{1}{2} T^2(F + F')$
Reinforcing Steel	nA_S	d	dnA_S
Stem above Neutral Axis	by	$\frac{1}{2} y$	$\frac{1}{2} by^2$

Adding area and moment columns:

(1) Total Area: $A = T(F + F') + dnA_S + by$

(2) Total Moment: $M = \frac{1}{2} T^2(F + F') + dnA_S + \frac{1}{2} by^2$ of which all except “by” in (1) and “$\frac{1}{2} by^2$” in (2) is know. Call the sum of these known value A' and M'. Then we have

(3) $A = A' + by$ and *(4)* $M = M' + \frac{by^2}{2}$

Since the Neutral Axis lies at the center of gravity, $Ay = M$. Then

(5) $y(A' + by) = M' + \frac{by^2}{2}$ *(6)* $A'y + by^2 = M' + \frac{by^2}{2}$

(7) $\frac{b}{2} y^2 + A'y - M' = 0$

General (Cont.):

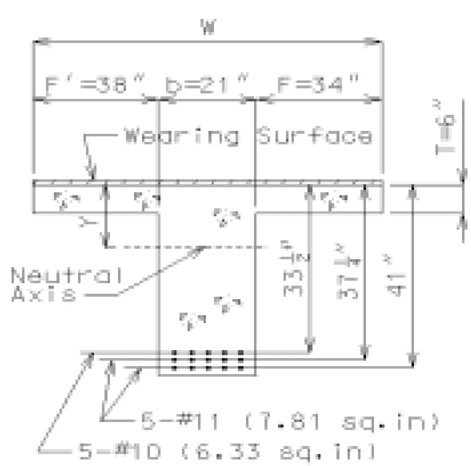
This equation is in the type form of the quadratic equation:

$$cy^2 + hy - K = 0$$

The coefficient of y^2 is always ½ the stem width. The coefficient of y is always the area of the flange outside the stem plus nAs.

The constant is always the moment, about the top of the effective concrete, of the above area; and is always preceded by a minus sign.

Design Example:



* Example shown is for Class B Concrete (n=10).
For Class B-1 Concrete use n=8.

Location of Neutral Axis

	Area	Arm	Moment
72 x 6 =	*432.00*	*3.00*	*1296*
(*)10 x 6.33 =	*63.30*	*33.50*	*2121*
(*)10 x 7.81 =	*78.10*	*37.25*	*2909*
(*)10 x 7.81 =	*78.10*	*41.00*	*3202*
Total	651.50 (sq. in)		9528(cu. in.)

$$10.5y^2 + 651.5y - 9528 = 0$$

$$y^2 + 62.04y + (31.02)^2 = 907.4 + (31.02)^2 = 1869.6$$

$$y = \sqrt{1869.6} - 31.02 = 43.24 - 31.02 = 12.22''$$

Evaluation of I

$$\frac{1}{3} \times 93 \times (12.22)^3 = 56569$$

$$-\frac{1}{3} \times 72 \times (6.22)^3 = -5775$$

$$+63.3 \times (21.28)^2 = 28665$$

$$+78.1 \times (25.03)^2 = 48930$$

$$+78.1 \times (28.78)^2 = 64689$$

$$\text{Total} \quad 193078 \ (\text{inch})^4$$

Moment: 1007 kips-ft.

Stresses

$$fc = \frac{1007000 \times 12 \times 12.22}{193078} = \frac{765\ lb}{sq.in.}$$

$$fs = \frac{1007000 \times 12 \times 28.78}{193078} \times 10(*) = \frac{18012\ lb}{sq.in.}$$

Special Cases

Should '*y*' be found to be less than *T:*
The Neutral Axis lies in the flange. The solution is based on a false assumption and must be discarded and the following procedure substituted:

In the equation $cy^2 + hy - K = 0$

c =1/2 the total flange and stem width = 1/2W
h = nA_S
K = the moment about top of concrete of nA_S and is preceded by minus sign in equation.

Special Cases (Cont.)

Should Flange Projections be of different depths:
Compute Area and Moment of each Projection separately and add results.

When Compressive Steel is used:
Include Area and Moment of $(n-1)A'_S$